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A Joint Program for Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing

Soil Moisture

June 1981

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GROUND REGISTRATION OF DATA FROM AN AIRBORNE SCATTEROMETER

John C. Richter

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Houston, Texas 77058

SM-L1-04091
JSC-17296

GROUND REGISTRATION OF DATA FROM AN AIRBORNE SCATTEROMETER

Job Order 71-323

This report describes activities of the Soil Moisture project of the AgRISTARS program.

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LOCKHEED ENGINEERING AND MANAGEMENT SERVICES COMPANY, INC.

Under Contract NAS 9-15800

For

Earth Resources Research Division

Space and Life Sciences Directorate

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

June 1981

LEMSCO-16340

PREFACE

The Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing is an 8-year program of research, development, evaluation, and application of aerospace remote sensing for agricultural resources, which began in fiscal year 1980. This program is a cooperative effort of the National Aeronautics and Space Administration; the U.S. Agency for International Development; and the U.S. Departments of Agriculture, Commerce, and the Interior.

The work which is the subject of this document was performed within the Earth Resources Research Division, Space and Life Sciences Directorate, at the Lyndon B. Johnson Space Center, National Aeronautics and Space Administration. Under Contract NAS 9-15800, personnel of Lockheed Engineering and Management Services Company, Inc., performed the tasks which contributed to the completion of this research.

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FIGURES

1. INTRODUCTION

Radar scatterometer measurements were taken by the National Aeronautics and Space Administration (NASA) C-130 aircraft at 1500 feet above ground level as part of the Agricultural Soil Moisture Experiment (ASME) near Colby, Kansas, on July 18, 20, 21, and 22 and on August 8, 9, and 11, 1978. These data are a measure of the efficiency of surface backscattering as seen from the sensor. Four radar scatterometers were mounted on the aircraft: 0.4, 1.6, 4.75, and 13.3 GHz. Their location on the aircraft is illustrated in figure 1. Each sensor collected data by looking aft with incidence angles between 5° and 50°. All angles were sensed simultaneously.

Soil samples from several layers were collected from preselected fields of approximately 40 acres on each of the 7 flight days. These samples were weighed, oven dried, and weighed again so that the moisture content of the layers could be calculated. They will be used for comparison with the scatterometer data.

The purpose of this report is to document a method of converting the scatterometer computer-compatible tape (CCT) data into disk files, wherein each file contains the date, the scatterometer data, and the ground reference position of the data within the sampled field. This conversion is accomplished by executing three programs on the National Advanced Systems AS/3000 computer, located in the Earth Observations Division Laboratory (EODL) in Building 17 at the NASA Lyndon B. Johnson Space Center (JSC). A listing and discussion of each program are given in this document.

2. REQUIRED INPUT DATA

As the plane flew down the flight line, the scatterometer data were recorded on tape in analog form. The tapes were sent to the Sensor Analysis Laboratory (SAL) in JSC Building 15. At the SAL, the analog data were subjected to a Doppler frequency shift filtering which separated the data by incidence angle. Then, the data were digitized and manipulated so that all incidence angles representing approximately the same target area were grouped together.

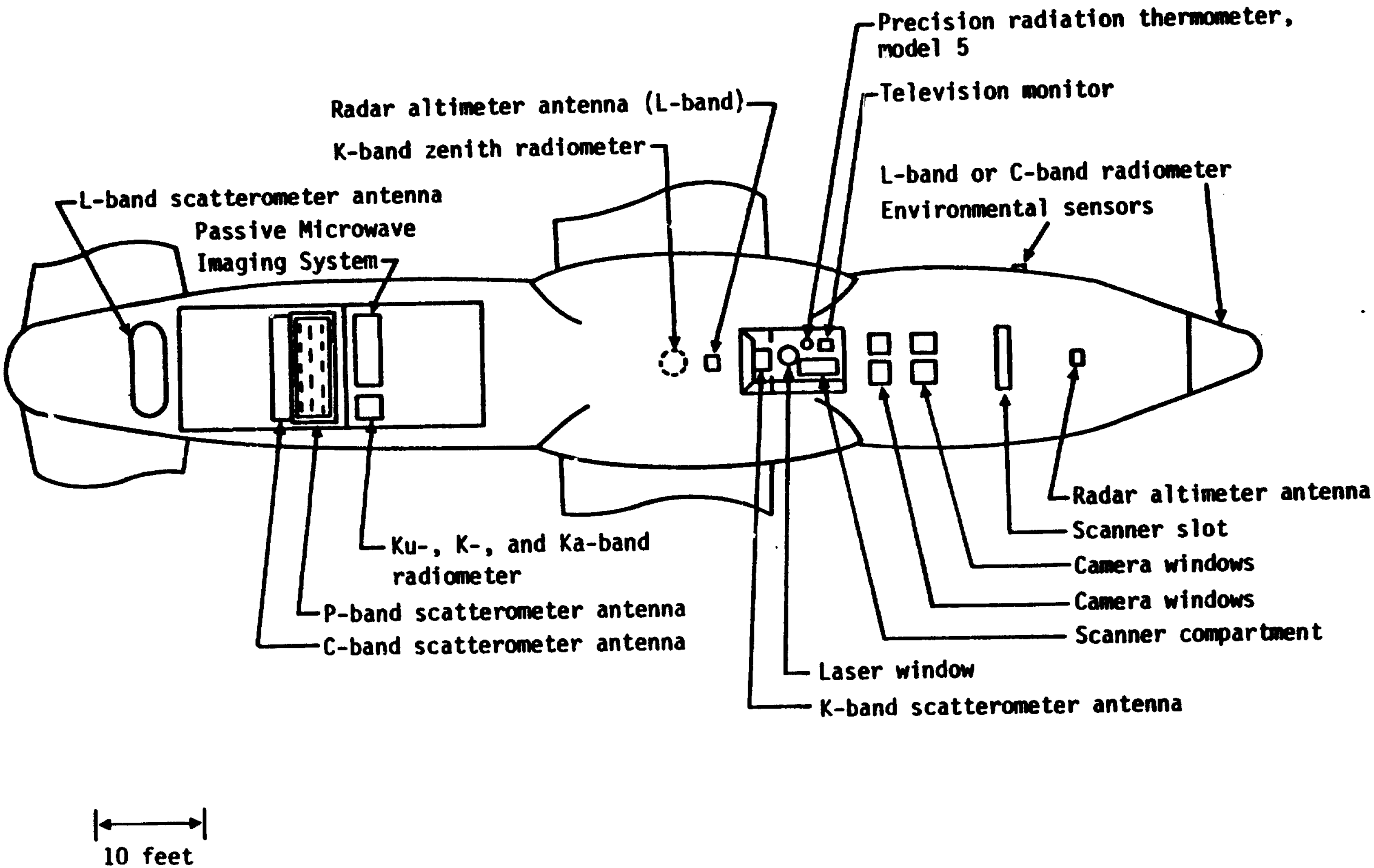

Figure 1.- Bottom view of the NASA C-130 aircraft.

In the case of the Colby ASME, the output CCT's from the SAL contain four files for each sensor on each run over a flight line. Only files 1 and 4 are required by the programs described in this document. The two files containing sensor calibration and bandwidth information (files 2 and 3, respectively) are not used.

File 1 contains the aircraft's flight parameters. Each record in the file contains the roll angle, pitch angle, drift angle, altitude, ground speed, and true heading angle of the aircraft referenced by the Auxiliary Data Annotation System (ADAS) time of measurement. New aircraft flight parameters were measured approximately every six-tenths of a second. A listing of a sample file is shown in figure 2.

File 4 on the CCT contains the scatterometer data. Figure 3 is a sample listing of this file. Each record in the file contains the backscatter coefficients, in decibels, for approximately the same area as viewed from 10 different incidence angles. They are referenced by the ADAS time when the aircraft passed over or closest to the target area. If the drift angle is nonzero, the areas viewed at various angles are unregistered and decorrelated.

A great deal of aerial photography was collected at the Colby test site. Photographs taken at an altitude of 8000 feet were used to construct controlled strip mosaics of each flight line. Additional aerial photography was acquired as the aircraft collected scatterometer data at altitudes of 1000 and 1500 feet. The acquisition time and the frame number of every photograph were recorded on the analog data system. This made it possible to determine the aircraft's position at the frame times. The camera positions and frame numbers were plotted on transparent overlays by the JSC Cartographic Technology Laboratory. Additional overlays were made showing the location of the sampled fields in each flight line. All overlays were made at the same scale as the strip mosaics.

FILE: FILE1 ADATA A EODL AS/3000 PAGE 001

SCATTEROMETER 13.3 MISSION 303 FLT 8 SITE 76 LINE 4 RUN 5 FLIGHT DATE: 7/21/78 POLARIZATION VV
PROJ 038771 OF 6

	GMT TIME	ROLL	PITCH	DRIFT	ALTITUDE	GROUND SPEED	HEADING
0.00	19: 8:45.2	0.10	2.20	-1.70	990.00	146.00	271.00
2.09	19: 8:47.3	-0.30	2.00	-1.10	1000.00	146.05	270.90
2.69	19: 8:47.9	-0.30	2.00	-0.80	1010.00	146.30	270.60
3.19	19: 8:48.4	-0.30	2.00	-0.80	1010.00	146.00	270.60
3.79	19: 8:49.0	-0.10	2.00	-0.40	1000.00	146.00	270.60
4.39	19: 8:49.6	-0.10	2.00	-0.80	1000.00	146.00	270.60
5.00	19: 8:50.2	0.10	2.00	-1.00	1000.00	146.00	270.60
5.50	19: 8:50.7	0.30	2.09	-1.00	1000.00	146.00	270.20
6.09	19: 8:51.3	0.90	2.09	-1.00	1000.00	146.00	270.20
6.59	19: 8:51.8	0.90	2.20	-0.80	990.00	146.00	270.20
7.19	19: 8:52.4	0.90	2.70	-0.80	1000.00	146.00	270.50
7.79	19: 8:53.0	1.00	2.20	-1.10	990.00	146.00	270.70
8.39	19: 8:53.6	0.90	2.30	-1.10	1000.00	146.00	271.70
9.00	19: 8:54.2	0.50	2.30	-1.50	1000.00	146.00	270.90
9.50	19: 8:54.7	0.20	2.30	-1.60	990.00	146.00	270.90
10.09	19: 8:55.3	-0.10	2.30	-1.60	1000.00	146.00	[illegible]
10.59	19: 8:55.8	-0.30	2.20	-1.30	1000.00	146.00	270.20
11.19	19: 8:56.4	-0.40	2.20	-1.30	1000.00	146.00	270.30
11.79	19: 8:57.0	-0.30	2.20	-1.10	990.00	146.00	[illegible]
12.39	19: 8:57.6	-0.20	2.20	-1.30	990.00	146.00	[illegible]
12.89	19: 8:58.1	0.00	2.40	-1.30	990.00	146.00	270.30
13.50	19: 8:58.7	0.10	2.60	-1.30	990.00	146.00	270.30
14.00	19: 8:59.2	0.10	2.90	-1.70	980.00	146.00	270.30
14.59	19: 8:59.8	0.40	3.00	-1.70	980.00	[illegible]	270.20
15.19	19: 9: 0.4	0.30	3.10	-1.80	970.00	146.00	270.20
15.79	19: 9: 1.0	0.50	3.10	-1.80	970.00	146.00	270.20
16.29	19: 9: 1.5	0.60	3.10	-1.80	970.00	145.00	270.20
16.69	19: 9: 2.1	0.70	2.90	-1.90	970.00	145.00	270.20
17.39	19: 9: 2.6	1.00	2.90	-1.90	970.00	145.00	270.20
18.00	19: 9: 3.2	1.30	2.70	-2.09	990.00	145.00	270.30
18.59	19: 9: 3.8	1.30	2.70	-2.09	990.00	145.00	270.30
19.19	19: 9: 4.4	1.30	2.60	-2.09	990.00	145.00	270.10
19.69	19: 9: 4.9	1.10	2.60	-1.70	990.00	145.00	270.10
20.29	19: 9: 5.5	0.90	2.60	-1.70	990.00	145.00	269.50
20.79	19: 9: 6.0	0.60	2.60	-1.10	990.00	145.00	269.10
21.39	19: 9: 6.6	1.30	2.70	-0.80	990.00	145.00	269.10
22.00	19: 9: 7.2	2.50	2.70	-0.80	990.00	145.00	269.20
22.59	19: 9: 7.8	2.90	2.70	-1.00	990.00	145.00	269.20
23.09	19: 9: 8.3	3.10	2.70	-1.00	1000.00	145.00	269.50
23.69	19: 9: 8.9	2.80	2.70	-1.00	990.00	145.00	269.70
24.19	19: 9: 9.4	2.30	2.60	-1.00	1000.00	144.00	269.70
24.79	19: 9:10.0	1.70	2.60	-1.00	1000.00	144.00	269.80
25.39	19: 9:10.6	1.00	2.60	-0.90	1000.00	144.00	269.80
26.00	19: 9:11.2	0.70	2.60	-0.90	1000.00	144.00	270.10
26.50	19: 9:11.7	0.50	2.60	-0.90	1000.00	144.00	270.40
27.09	19: 9:12.3	0.40	2.60	-1.10	1000.00	144.00	270.40
27.59	19: 9:12.8	0.40	2.70	-1.10	1000.00	144.00	270.40
28.19	19: 9:13.4	0.50	2.70	-1.40	1000.00	144.00	270.60
28.79	19: 9:14.0	0.90	2.70	-1.70	990.00	144.00	270.60
29.39	19: 9:14.6	0.70	2.70	-1.70	990.00	145.00	270.60
29.89	19: 9:15.1	0.40	2.50	-1.60	990.00	145.00	270.30
30.50	19: 9:15.7	1.10	2.50	-1.60	1000.00	144.00	270.30
31.00	19: 9:16.2	1.30	2.40	-1.40	990.00	144.00	270.10
31.59	19: 9:16.8	1.40	2.50	-1.10	990.00	144.00	270.10
32.19	19: 9:17.4	1.50	2.50	-1.10	1000.00	144.00	269.90
32.79	19: 9:18.0	1.50	2.50	-0.90	1000.00	144.00	269.90
33.29	19: 9:18.5	1.50	2.50	-0.90	990.00	144.00	269.80
33.89	19: 9:19.1	1.60	2.40	-0.90	1000.00	144.00	270.10
34.39	19: 9:19.6	1.90	2.40	-0.90	1000.00	144.00	270.10
35.00	19: 9:20.2	1.40	2.40	-1.10	1000.00	144.00	270.40
35.59	19: 9:20.8	2.00	2.40	-1.10	1000.00	144.00	270.40
36.19	19: 9:21.4	2.00	2.40	-1.30	1010.00	145.00	270.70
36.79	19: 9:22.0	2.00	2.40	-1.30	1010.00	145.00	270.80
37.29	19: 9:22.5	2.00	2.40	-1.40	1010.00	145.00	270.80
37.89	19: 9:23.1	2.00	2.40	-1.40	1010.00	145.00	270.80
38.39	19: 9:23.6	1.90	2.40	-1.40	1010.00	145.00	270.90
39.00	19: 9:24.2	1.90	2.40	-1.40	1000.00	145.00	270.90
39.59	19: 9:24.8	1.70	2.30	-1.40	1000.00	145.00	271.20
40.19	19: 9:25.4	1.60	2.20	-1.60	1000.00	145.00	271.00
40.69	19: 9:25.9	1.50	2.09	-1.60	1000.00	145.00	271.00
41.29	19: 9:26.5	1.40	2.09	-2.00	1000.00	145.00	272.30
41.79	19: 9:27.0	1.40	2.09	-2.40	1000.00	145.00	272.30
42.39	19: 9:27.6	1.40	2.09	-2.40	1000.00	145.00	272.70
42.90	19: 9:28.2	1.50	2.09	-2.60	990.00	145.00	272.70
43.59	19: 9:28.8	1.90	2.09	-2.60	1000.00	145.00	272.70
44.09	19: 9:29.3	2.00	2.00	-2.60	990.00	146.00	272.60

Figure 2.- A sample listing of the file containing the aircraft's flight parameters.

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FILE: FILE4 XDATA A EOOL AS/3000 PAGE 001

SDL LAB(MLD.IS) SIGMA ZERO VS INCIDENCE ANGLE 06:51:58 09-OCT-80

NADIR CELL TIME AFT INCIDENCE ANGLES(DEGREES)

HR MIN SEC	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0
19: 8:45.00	6.51961	3.12206	-1.22293	-5.05616	-7.13088	-7.88361	-9.85687	-10.55877	-10.31094	-11.46225
19: 8:45.50	6.95344	2.83686	-1.15308	-4.25809	-6.53475	-8.11148	-9.66482	-10.09351	-10.21815	-11.91231
19: 8:46.00	6.82567	2.71020	-0.95890	-3.80957	-6.35226	-8.32090	-9.95362	-10.17010	-9.99201	-11.91278
19: 8:46.50	5.85378	2.98127	-0.72452	-3.95341	-6.20533	-8.37497	-9.87681	-10.19580	-11.47633	-11.24512
19: 8:47.00	5.30766	3.21589	-0.74308	-3.98956	-5.95781	-8.03846	-9.95920	-10.60595	-11.30797	-12.02683
19: 8:47.50	6.65168	3.01844	0.15694	-3.74155	-5.69968	-7.60034	-9.93212	-10.67799	-10.03638	-10.41002
19: 8:48.00	7.83530	7.48845	2.97679	-1.30836	-4.75081	-6.60529	-9.52956	-9.93170	-9.85934	-9.75709
19: 8:48.50	10.70602	9.63969	5.61902	-0.12270	-4.12599	-6.10844	-9.05709	-8.89210	-10.08067	-10.11553
19: 8:49.00	10.76291	10.28875	5.99048	-0.56821	-4.21086	-6.65994	-9.05896	-8.90520	-9.74953	-10.23659
19: 8:49.50	11.12217	10.20092	3.93584	-0.88262	-4.58852	-6.74981	-8.11089	-8.56013	-10.10763	-10.20015
19: 8:50.00	11.14050	9.69516	3.04185	-1.13067	-4.10566	-5.78362	-8.77106	-8.84534	-9.32494	-10.98669
19: 8:50.50	9.77900	5.75660	1.21014	-2.62370	-6.11624	-7.96409	-10.88519	-10.95203	-12.14921	-12.14827
19: 8:51.00	5.92246	2.23031	-2.56666	-6.60761	-8.97961	-10.80309	-12.75044	-12.00709	-13.63492	-14.03290
19: 8:51.50	4.98093	0.94170	-3.66483	-7.47040	-9.00698	-10.93675	-13.32557	-13.26720	-14.37003	-14.81595
19: 8:52.00	4.73432	0.50087	-3.47100	-7.70074	-9.16215	-11.16297	-13.11155	-13.07951	-14.44104	-14.27250
19: 8:52.50	4.44565	0.22233	-3.35206	-7.23310	-9.35621	-11.03175	-12.38008	-12.74555	-14.21969	-13.31300
19: 8:53.00	4.45999	0.81955	-3.71633	-6.93710	-8.98536	-10.64952	-12.73056	-13.47330	-14.16534	-13.67079
19: 8:53.50	6.45751	1.07869	-2.66805	-8.43738	-8.20406	-9.81838	-12.50608	-12.86119	-13.92567	-14.33734
19: 8:54.00	6.10421	1.29909	-2.82962	-8.46604	-8.35461	-10.20731	-12.96675	-12.90180	-12.60006	-14.50190
19: 8:54.50	4.41294	0.62243	-3.29140	-7.80846	-9.06626	-10.10985	-12.93116	-13.03145	-13.96127	-14.35679
19: 8:55.00	4.45267	0.57714	-3.93677	-7.04235	-9.14483	-10.07627	-12.80429	-13.37950	-13.76230	-13.63402
19: 8:55.50	4.52859	0.56753	-4.14615	-7.14766	-9.50829	-10.95243	-12.57138	-13.17311	-13.60832	-13.61533
19: 8:56.00	5.12457	0.40012	-3.07838	-7.36039	-9.30756	-10.76311	-12.26917	-12.61344	-13.91030	-12.76228
19: 8:56.50	4.61616	0.11575	-4.65527	-7.14026	-9.25346	-10.73127	-12.13193	-12.43577	-13.80089	-13.02678
19: 8:57.00	4.94511	0.15757	-4.34115	-7.33573	-9.20334	-10.05200	-12.73727	-13.15097	-13.71542	-13.76029
19: 8:57.50	4.81868	0.48317	-4.49133	-7.72120	-8.87424	-9.83357	-12.71101	-12.47600	-13.53000	-13.70355
19: 8:58.00	4.71724	0.51759	-3.94776	-7.38790	-8.31118	-9.74546	-12.94752	-12.47672	-13.03040	-13.08300
19: 8:58.50	5.49448	1.05131	-3.50673	-6.85320	-8.29901	-9.48429	-12.87058	-13.00750	-13.20119	-13.70530
19: 8:59.00	6.06910	1.08778	-2.95539	-6.30481	-8.11201	-9.30827	-11.57363	-13.17491	-13.20140	-14.31511
19: 8:59.50	6.08113	1.08148	-2.77540	-6.09723	-7.91911	-9.33617	-11.58439	-12.39233	-13.30507	-13.27873
19: 9: 0.00	6.05152	1.05887	-3.00671	-6.21033	-7.84176	-9.04305	-11.96143	-12.21044	-12.90121	-13.23222
19: 9: 0.50	5.55600	0.53526	-2.75506	-7.12196	-8.20008	-8.84309	-16.53505	-11.86633	-12.50829	-12.29702
19: 9: 1.00	5.69498	2.61121	-0.53804	-3.32532	-4.70806	-6.10159	-7.87779	-8.90261	-9.81196	-10.60090
19: 9: 1.50	7.28958	4.70174	2.49509	-1.13676	-2.51834	-3.60744	-5.34337	-7.22210	-7.89240	-8.39005
19: 9: 2.00	7.55698	5.25212	1.90002	-0.09770	-2.01329	-3.13453	-5.07334	-6.71719	-6.73954	-8.45509
19: 9: 2.50	7.73924	4.93640	2.10197	-0.92153	-1.83459	-3.42965	-5.59709	-7.01610	-8.07509	-8.74601
19: 9: 3.00	8.30707	5.54051	2.27875	-0.09890	-2.03891	-3.20956	-6.11510	-7.55007	-7.60607	-8.00409
19: 9: 3.50	9.12372	6.38995	2.39237	-1.32007	-2.99951	-3.05774	-6.28075	-7.67917	-8.06505	-9.04102
19: 9: 4.00	9.94271	6.22365	1.59204	-2.24138	-3.01338	-4.40173	-6.73578	-8.26489	-9.20993	-10.20995
19: 9: 4.50	7.50500	5.55164	1.12011	-2.99810	-3.56782	-4.02339	-7.12194	-8.37050	-9.30723	-11.11129
19: 9: 5.00	8.34711	4.82824	1.52401	-1.93842	-3.21667	-4.53404	-6.63017	-7.59720	-8.04095	-9.00009
19: 9: 5.50	7.71604	4.58240	0.83901	-2.80746	-3.00935	-4.90600	-6.64913	-7.70525	-8.53475	-9.35099
19: 9: 6.00	7.92153	4.71986	1.43844	-1.93640	-3.08805	-4.20523	-7.04021	-8.08801	-9.34902	-9.00173
19: 9: 6.50	8.59312	4.92079	1.25093	-2.04081	-3.11007	-4.43029	-6.70840	-8.60076	-9.36931	-9.67918
19: 9: 7.00	8.72316	4.60952	0.80179	-1.96081	-3.04176	-3.80472	-6.62582	-8.19900	-8.20972	-9.40274
19: 9: 7.50	8.69472	4.74813	0.74633	-1.77315	-3.40081	-4.47604	-6.80092	-7.91119	-8.82123	-8.80051
19: 9: 8.00	9.21217	4.62993	1.14601	-2.20620	-3.45807	-4.50354	-7.02292	-8.33561	-8.82055	-8.87403
19: 9: 8.50	8.69932	5.24488	1.76690	-1.43720	-3.27529	-4.12651	-6.92501	-7.97032	-8.57344	-9.22929
19: 9: 9.00	8.57805	5.74802	2.69123	-1.10465	-2.31291	-3.71200	-6.26594	-8.02100	-8.20305	-9.05277
19: 9: 9.50	10.02531	6.02044	3.76908	0.17307	-2.12820	-3.30200	-6.05095	-7.35115	-8.10990	-10.00439
19: 9:10.00	9.63211	6.94930	3.87779	-0.65248	-2.12305	-3.00408	-5.54312	-7.10070	-8.11007	-9.61752
19: 9:10.50	8.74082	6.37307	3.25908	-1.11602	-1.05612	-3.24007	-5.24701	-7.34908	-7.84302	-8.29212
19: 9:11.00	8.34581	5.84235	1.94433	-1.75900	-2.49046	-3.52937	-6.03005	-7.49718	-7.05203	-8.00174
19: 9:11.50	7.35003	2.95412	-0.59216	-2.90000	-4.20674	-5.82965	-7.33129	-7.96303	-8.03049	-8.30163
19: 9:12.00	4.27871	0.55016	-2.05046	-4.10354	-4.90393	-4.69901	-6.96176	-7.36743	-7.99597	-7.94635
19: 9:12.50	2.64260	-0.01866	-1.85110	-3.64307	-4.24138	-4.80221	-6.15167	-7.06108	-7.37940	-7.72500
19: 9:13.00	1.65198	-0.35040	-1.64992	-3.81002	-4.54648	-4.99468	-5.81311	-7.20625	-7.02070	-7.60016
19: 9:13.50	1.78372	-0.00180	-1.57404	-4.09743	-4.69008	-4.79266	-5.03005	-7.32529	-7.30017	-8.00276
19: 9:14.00	2.39311	0.11655	-1.62034	-3.42293	-4.31207	-4.33215	-5.20453	-6.92163	-6.50005	-7.99310
19: 9:14.50	2.48318	-0.02780	-1.54904	-3.35652	-3.33205	-4.00706	-5.02676	-6.90070	-6.91030	-7.80097
19: 9:15.00	2.55219	0.31829	-2.05784	-3.21155	-4.02499	-4.34114	-5.13588	-6.76930	-6.74203	-8.15160
19: 9:15.50	2.49730	0.76337	-1.90985	-3.49907	-4.15594	-4.20400	-6.20027	-6.76013	-8.02203	-8.93164
19: 9:16.00	2.51129	0.56957	-2.07795	-3.71142	-3.59219	-4.41290	-6.20109	-6.90999	-7.62331	-8.00250
19: 9:16.50	3.31452	0.14530	-3.77102	-2.52676	-3.31050	-3.05719	-5.24435	-6.39702	-6.09902	-7.63451
19: 9:17.00	4.73711	3.79962	0.89355	-1.19072	-0.62205	-1.95503	-4.10590	-5.65625	-6.94999	-7.55090
19: 9:17.50	5.62734	3.40055	1.31082	-0.72508	-1.16236	-1.77794	-4.22310	-5.93910	-6.93123	-7.53431
19: 9:18.00	3.07665	1.96849	-0.33039	-1.34022	-2.51959	-2.01321	-5.20099	-6.11037	-6.75315	-7.64210
19: 9:18.50	2.14106	1.37047	-0.56532	-1.80900	-3.01420	-2.29005	-5.10670	-6.15675	-7.34332	-7.76901
19: 9:19.00	3.65240	1.98063	0.76575	-1.45626	-2.20520	-2.01402	-5.51191	-6.60590	-6.71235	-8.19102
19: 9:19.50	4.60200	3.13873	1.10006	-0.77163	-1.20277	-2.13076	-4.76655	-6.29731	-9.52040	-8.61538
19: 9:20.00	4.69860	3.07566	1.15089	0.03190	-1.18103	-1.97535	-4.63519	-6.07377	-7.32025	-8.19669
19: 9:20.50	4.81552	3.19921	1.74554	0.01060	-1.32049	-2.56773	-4.86571	-6.39330	-7.19191	-7.94563
19: 9:21.00	3.81318	3.32570	1.30034	-0.65665	-2.12620	-2.56659	-4.80716	-6.71051	-7.69363	-7.90599
19: 9:21.50	4.27958	2.66960	0.42709	-1.26333	-2.14876	-2.97419	-5.28561	-6.83249	-7.71187	-7.32577
19: 9:22.00	5.14710	3.00717	1.13060	-1.69108	-2.23260	-3.71146	-6.22373	-7.26399	-7.94191	-8.50000
19: 9:22.50	5.25614	3.49532	1.40767	-1.93951	-2.80490	-4.19331	-6.15302	-8.42007	-8.35517	-8.89500

Figure 3.- A sample listing of the file containing the scatterometer data.

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3. PROGRAM EXPLANATION

3.1 SCAT

The first program used to process the scatterometer data is a Fortran program called SCAT. A listing of the program and its execute file are given in the appendix. This program reads files 1 and 4 after they have been transferred from the CCT to a disk. The program uses these data to compute the intersection of the aircraft's negative z-axis with the ground in a scene-based coordinate system.

Three inputs from the terminal are requested by the program. The first input, AMISS, is the northward distance (in feet) of the plane from the southern field boundaries, if the flight line runs east-west, or westward from the eastern field boundaries for north-south flight lines, at the beginning of the flight line. The second input, YUP, is the crosstrack distance (in feet) that the airplane's position is from the reference field boundary at the end of the flight line. Figure 4 is a diagram of a flight line and shows the distances represented by AMISS and YUP. Both distances are measured (in millimeters) with the overlay on the strip mosaic. The final input requested is called CODE. It is a three-symbol numeric identifier for the day, sensor, and polarization of the data. The codes used for the Colby ASME are shown in table 1.

Program SCAT creates two output files. One file contains the downtrack and crosstrack locations of the airplane at each time that aircraft flight parameters were available. The second output file contains the scatterometer data and the location of the aircraft's negative z-axis intersection with the ground with respect to the beginning of the flight line. The file also contains the distance (in feet) of footprint decorrelation caused by aircraft drift. This distance represents the difference in crosstrack location of the 5° and 50° sensor footprints.

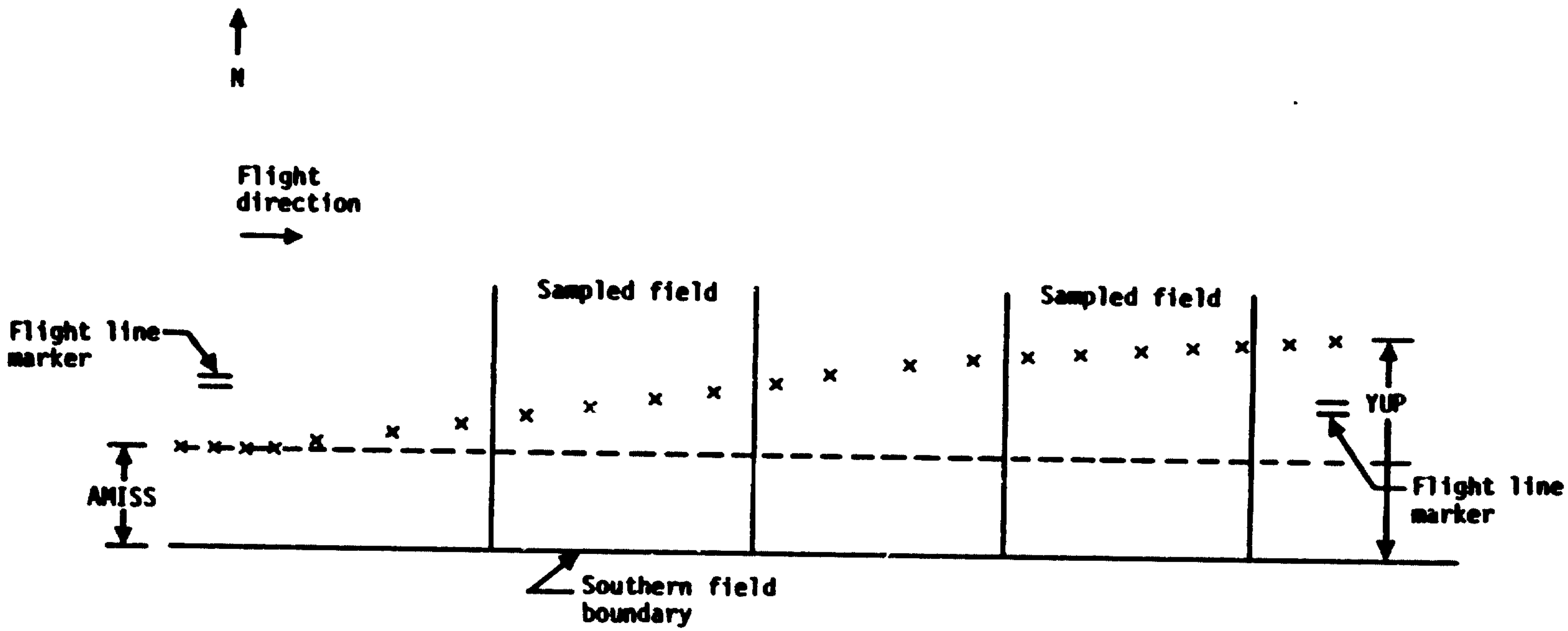

Figure 4.- A sample plot illustrating how and where to measure the variables AMISS and YUP.

TABLE 1.- CODES FOR THE COLBY SCATTEROMETER DATA

Code	Day, 1978	Sensor, GHz	Polarization[a]
1	199 - 7/18	13.3	VV
2	201 - 7/20	4.75	VH
3	202 - 7/21	1.6	HV
4	203 - 7/22	0.4	HH
5	220 - 8/08		
6	221 - 8/09		
7	223 - 8/11		

[a]VV = vertical transmit and vertical receive,
VH = vertical transmit and horizontal receive,
HV = horizontal transmit and vertical receive, and
HH = horizontal transmit and horizontal receive.

3.2 PLOT

The second program, PLOT, is a Statistical Analysis System (SAS) program. This program reads the two files output by program SCAT and produces a printer plot of the aircraft's ground track along with the corresponding 20° scatterometer data. The plot is at the same scale as the strip mosaics. The 20° incidence angle was chosen because it was judged to be most responsive to row direction effects. The advantage of this will be explained later in this paper. A portion of the plot is shown in figure 5, and a program listing is given in the appendix. At this point in the analysis, the scatterometer data are referenced by the distance (in feet) down track and the distance from the southern or eastern field boundaries, depending upon the direction of the flight line. It is necessary to know the ground reference position of the data within the sampled fields. This is accomplished by using the overlays in conjunction with the plot. Both overlays, one with photographic position and the other with field boundaries, are placed on the plot in the following manner. First, a time is found when the aircraft's flight parameters are available and when an aerial photograph was taken. The time represented by each asterisk in the flight path plot can be found by using the exclamation points plotted along side. The exclamation points are time marks when the aircraft clock was at the

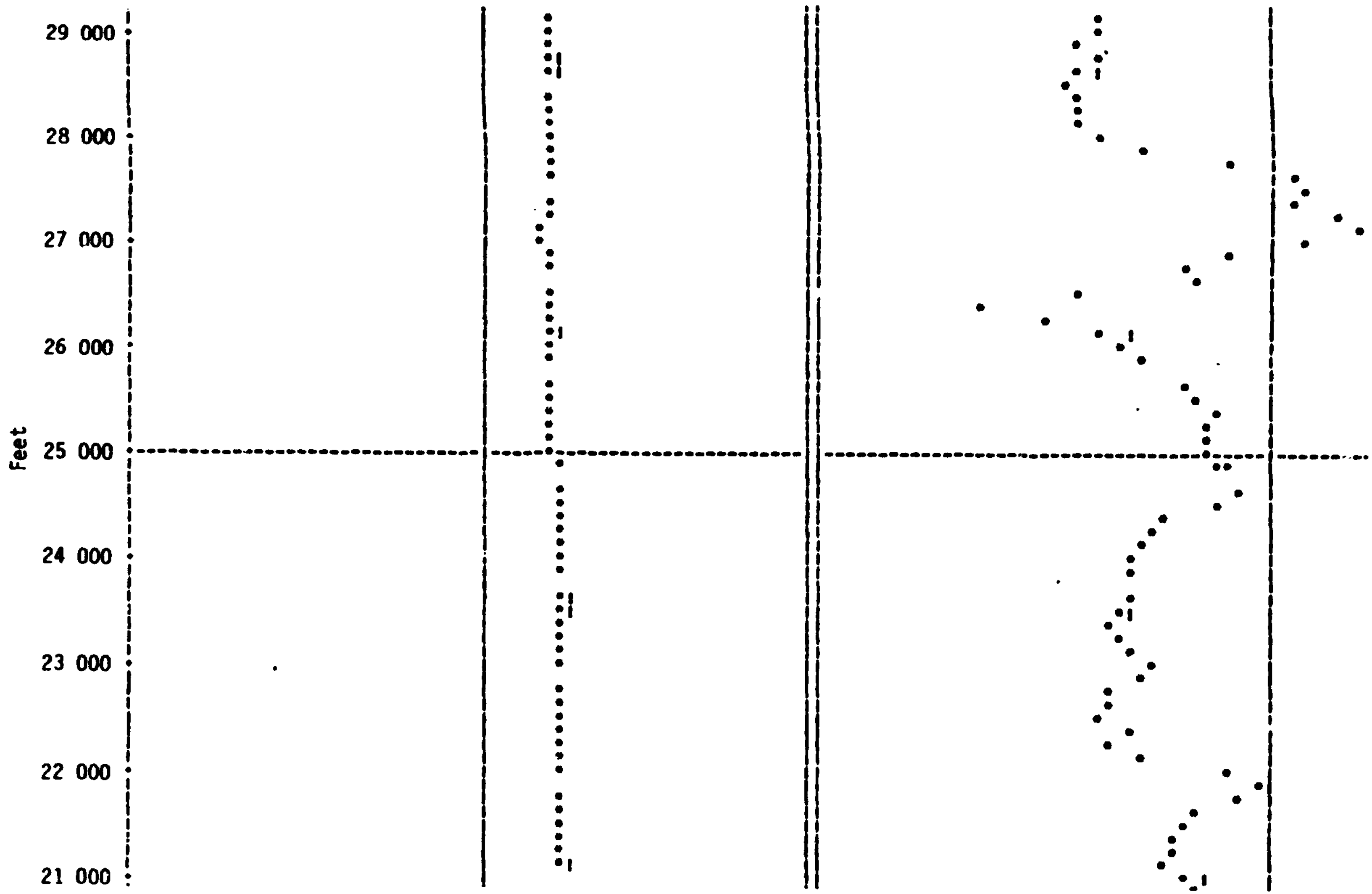

Figure 5.- A portion of the plot depicting the aircraft's ground track.

minute or a multiple of 10 seconds after the minute. Next, the overlays are placed on the plot so that the photographic position from the overlay is on top of the asterisk representing the same time. The solid line paralleling the plot of the flight path should be even with the southern field boundaries for an east-west flight or with the eastern field boundaries for a north-south flight. Figure 6 is an illustration of the plot with the overlays in place. The downtrack distance (in feet) of each field's closest boundary to the beginning of the flight line is read from the plot. These distances, along with the dimensions of the corresponding fields, are written in a separate file. This file is used as an input to the next program.

When the procedure is carried out in the manner described above, a discrepancy may become apparent. If the overlay and plot were registered at an extreme end of the flight line, the overlay and plot positions will not necessarily correspond at the opposite end. This is due to a lack of sufficient accuracy in recording the airplane's flight parameters. Therefore, it is recommended that the overlay and plot be registered at several points along the flight line. The plot of the 20° scatterometer values is useful for a final, small adjustment in the alongtrack direction.

The row direction of the fields can be determined from the aerial photography. Since the 20° scatterometer angle is highly responsive to row direction effects, knowledge of how the row direction changes from field to field can aid in determining exactly which points fall in the sampled field.

3.3 GRID

The GRID program reads in the boundary data file, along with the file containing the scatterometer data that was created by program SCAT. A listing of this Fortran program and its execute file are given in the appendix. A separate output file is generated for each sampled field within the flight line. Each record in the file contains the distance (in feet) from the 30° footprint to the northern and the western field boundaries, along with the corresponding scatterometer data and decorrelation distance. The output files can then be combined in the manner which best suits the analysis techniques that will be used.

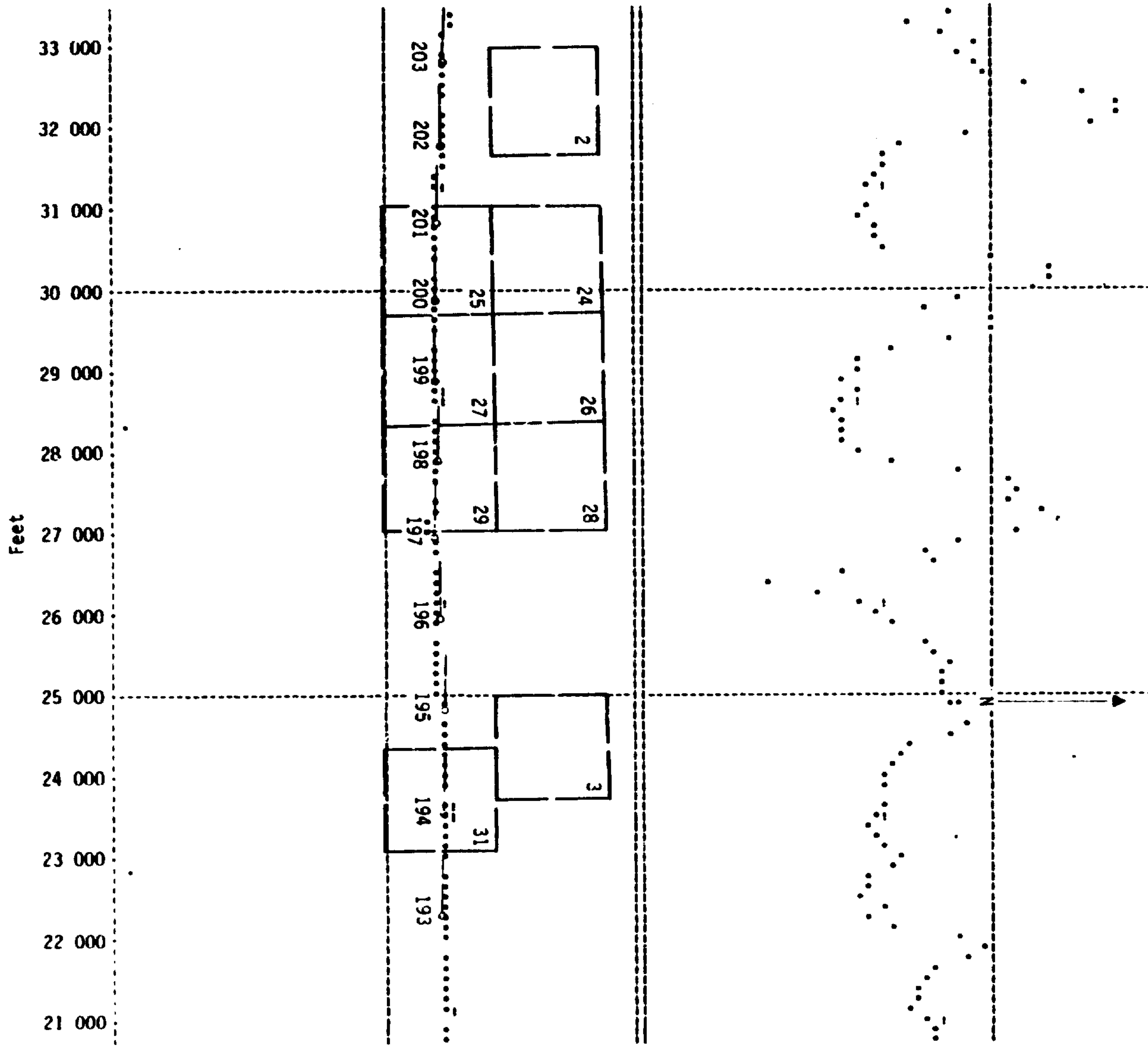

Figure 6.- Illustration of the plot of the aircraft's ground track with overlays indicating the photographic position and field boundaries.

APPENDIX

PROGRAM LISTINGS AND EXECUTE FILES

APPENDIX

PROGRAM LISTINGS AND EXECUTE FILES

A listing for program SCAT and its execute file are provided in figures A-1 and A-2, respectively. The listing for program PLOT is given in figure A-3. Figures A-4 and A-5 are respectively the listing and execute file for program GRID.

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                      C
C   THIS IS THE FIRST OF THREE PROGRAMS USED TO CONVERT THE SCATTER-   C
C   OMETER DATA TAPES FROM THE SENSOR ANALYSIS LAB INTO A FORMAT       C
C   THAT FACILITATES COMPARISON TO THE SOIL MOISTURE GROUND TRUTH      C
C                                                                      C
C   THE INPUT PARAMETERS FROM UNIT 10 ARE:                             C
C                                                                      C
C     F1 AND F2 = CONTAIN THE FREQUENCY OF THE SENSOR IN A2 FORMAT     C
C     ILINE     = THE NUMBER OF THE FLIGHT LINE                        C
C     IRUN      = THE NUMBER OF THE RUN                                C
C     IDAY      = CALENDAR DAY NUMBER                                  C
C     POLAR     = THE POLARIZATION OF THE SENSOR DATA IN A2 FORMAT     C
C     ET        = THE ELAPSED TIME OF THE RUN                          C
C     IMIN      = THE NUMBER OF MINUTES ON THE AIRCRAFT CLOCK          C
C     SEC       = THE NUMBER OF SECONDS AND TENTHS ON THE CLOCK        C
C     ROLL      = THE AIRCRAFT ROLL IN DEGREES AND TENTHS              C
C                  A POSITIVE ROLL IS WHEN THE RIGHT WING IS DOWN      C
C     PITCH     = THE AIRCRAFT PITCH IN DEGREES AND TENTHS             C
C                 A POSITIVE PITCH IS WHEN THE NOSE IS UP              C
C     DRIFT     = THE AIRCRAFT DRIFT IN DEGREES AND TENTHS             C
C                 A POSITIVE DRIFT IS CLOCKWISE FROM HEADING           C
C     ALT       = THE AIRCRAFT ALTITUDE IN FEET                        C
C     SPEED     = THE AIRCRAFT GROUND SPEED IN KNOTS                   C
C     HEAD      = THE AIRCRAFT HEADING IN DEGREES AND TENTHS           C
C                                                                      C
C   THE INPUT PARAMETERS FROM UNIT 11 ARE:                             C
C                                                                      C
C     KMIN      = THE NUMBER OF MINUTES ON THE AIRCRAFT CLOCK          C
C     SEC       = THE NUMBER OF SECONDS AND TENTHS ON THE CLOCK        C
C     SIGZ      = AN ARRAY CONTAINING THE SCATTEROMETER DATA FOR       C
C                 ONE FOOTPRINT                                        C
C                                                                      C
C   THE OUTPUT PARAMETERS TO UNIT 12 ARE:                              C
C                                                                      C
C     TOTX      = THE DOWNTRACK DISTANCE (IN FEET) OF THE AIRCRAFT     C
C                 FLIGHT PARAMETERS                                    C
C     TOTY      = THE DISTANCE (IN FEET) TO THE SOUTHERN/EASTERN       C
C                 FIELD BOUNDARIES FOR THE FLIGHT PARAMETERS           C
C     ITEN      = USED TO PUT TIME MARKS ON THE PLOT                   C
C                                                                      C
C   THE OUTPUT PARAMETERS TO UNIT 13 ARE:                              C
C                                                                      C
C     SMEAR     = THE FOOTPRINT DECORRELATION DISTANCE                 C
C     SCATX     = THE DOWNTRACK DISTANCE (IN FEET) OF THE              C
C                 SCATTEROMETER DATA                                   C
C     SCATY     = THE DISTANCE (IN FEET) TO THE SOUTHERN/EASTERN       C
C                 FIELD BOUNDARIES FOR THE SCATTEROMETER DATA          C
C     KTEN      = USED TO PUT THE TIME MARKS ON THE PLOT               C
C     ISIGZ     = AN ARRAY THAT CONTAINS THE SCATTEROMETER DATA FOR    C
C                 ALL ANGLES IN ONE FIELD                              C
C                                                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      INTEGER ITIME(510),KTIME(510),ISIGZ(510,10)
      REAL TOTX(510),TOTY(510),ITEN(510),ACSEC(510),DECORR(510)
      REAL SCATS(510),YOFF(510),SCATY(510),DRIFT(510)
      REAL SIGZ(10),SCATX(510),KTEN(510),TRACK(510),SPEED(510)
      REAL SMEAR(510)
C
C   THESE STATEMENTS ASK FOR AND READ INFORMATION FROM THE TERMINAL
C
      WRITE(16,161)
  161       FORMAT('INPUT AMISS AND YUP IN F3.0,F3.0')
      READ(15,151)AMISS,YUP
  151       FORMAT(F3.0,F3.0)
      WRITE(16,162)
  162       FORMAT('TYPE IN THE THREE NUMBER CODE FOR DAY/FREQ/POLAR')
      READ(15,152)IC1,IC2,IC3
  152       FORMAT(3I1)
      YUP=((AMISS-YUP)/25.4)*1000.0
      AMISS=(AMISS/25.4)*1000.0
      CHGSN=1.0
      YOLD=0.0
      HTOT=0.0
      TOTY(1)=0.0
      TOTX(1)=0.0
C
C   THESE STATEMENTS READ IN AND MANIPULATE THE AIRCRAFT DATA
```

Figure A-1.- Computer listing for program SCAT.

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```
C
      READ(10,106)F1,F2,ILINE,IRUN,IDAY,POLAR
  106     FORMAT(T17,A4,A2,T65,I2,T72,I2,T90,I2,T110,A2)
        IF(ILINE.EQ.1)CHGSN=-1.0
        IF(ILINE.EQ.4)CHGSN=-1.0
        IF(ILINE.EQ.5)CHGSN=-1.0
      DO 15 M=1,2
   15   READ(10,105)DUMMY
  105       FORMAT(A4)
        IFLAG=0
      DO 1 I=1,510
       READ(10,101,END=201)ET,IMIN,SEC,ROLL,PITCH,DRIFT(I),ALT,SPEED(I),
     6 HEAD
  101     FORMAT(T2,F5.2,T12,I2,T15,F4.1,T26,F6.2,T36,F6.2,T46,F6.2,
     6    T55,F7.2,T66,F6.2,T76,F6.2)
        MIN=FLOAT(IMIN)
        ACSEC(I)=(MIN*60.0)+SEC
        DTOR=(ROLL*3.141593)/180.0
        YOFF(I)=ALT*TAN(DTOR)
        NUMBAC=I-1
        IMIN=IMIN*1000
        ISEC=IFIX(SEC*10.0)
        ITIME(I)=IMIN+ISEC
        SPEED(I)=SPEED(I)*1.6878
        IF(HEAD.LT.40.0)HEAD=HEAD+360.0
        ICHK=ITIME(I)-ITIME(I-1)
        IF(ICHK.GT.30)IFLAG=1
        IF(ICHK.LT.-50000)IFLAG=2
        IF(IFLAG.EQ.1)ITIME(I)=ITIME(I)-400
        IF(IFLAG.EQ.2)ITIME(I)=ITIME(I)+60000
        IF(IFLAG.EQ.2)ACSEC(I)=ACSEC(I)+3600.0
    1   TRACK(I)=DRIFT(I)+HEAD
  201    CONTINUE
        YUP=YUP/(ET*SPEED(NUMBAC))
        NN=NUMBAC+1
C
C  THESE STATEMENTS COMPUTE THE AVERAGE FLIGHT DIRECTION
C
        NN=FLOAT(NN)
      DO 14 K=1,NN
   14  HTOT=HTOT+TRACK(K)
        HAVG=HTOT/ANN
C
C  THIS SECTION COMPUTES THE LOCATION OF THE AIRCRAFT
C
      DO 11 I=1,NUMBAC
          TOTD=0.0
      DO 18 KJ=1,10
          JJ=KJ+I-1
   18    TOTD=TOTD+DRIFT(JJ)
        AVGD=((TOTD/10.0)*3.141593)/180.0
        DECURR(I)=(TAN(AVGD)*1350.0)*CHGSN
        ELPTME=FLOAT(ITIME(I+1)-ITIME(I))/10.0
        ANGLE=(((HAVG-TRACK(I)))*3.141593)/180.0
        DISP=ELPTME*SPEED(I)
        XDISP=DISP*COS(ANGLE)
        YDISP=DISP*SIN(ANGLE)*CHGSN
        L=I+1
        IF(I.EQ.1)GO TO 12
          YDIFF=(YOFF(I)-YOFF(I-1))*CHGSN
          TOTX(L)=TOTX(L-1)+XDISP
          TOTY(L)=TOTY(L-1)+YDISP+YDIFF+(YUP*TOTX(L)-YUP*TOTX(L-1))
          GO TO 11
   12   TOTX(L)=XDISP
          TOTY(L)=YDISP+YOFF(I)+AMISS
   11 CONTINUE
C
C  THIS SECTION DETERMINES WHICH AIRCRAFT DATA IS AT 10 SECONDS
C
      DO 8 I=2,NUMBAC
         L=I-1
         ITEN(I)=0.0
         ITEMP=ITIME(I)/100
         IDIFF=ITIME(I)-(ITEMP*100)
         IF(IDIFF.LE.3)ITEN(I)=TOTY(L)+100.0
         IF(IDIFF.GT.96)ITEN(I)=TOTY(L)+100.0
    8 CONTINUE
C
C  THIS SECTION READS IN THE SIGMA ZERO'S
```

Figure A-1.- Continued.

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```
C
      DO 16 M=1,3
   16   READ(11,107)DUMMY
  107     FORMAT(A4)
       KFLAG=0
      DO 2 K=1,510
        READ(11,102,END=202)KMIN,SEC,(SIGZ(M),M=1,10)
  102     FORMAT(T5,I2,T8,F4.1,T16,10F11.5)
      DO 17 N=1,10
   17   ISIGZ(K,N)=IFIX(SIGZ(N)*10.0)
       NUMBSO=K
       MIN=FLOAT(KMIN)
       SCATS(K)=(MIN*60.0)+SEC
       KMIN=KMIN*1000
       KSEC=IFIX(SEC*10.0)
       KTIME(K)=KMIN+KSEC
       KCHK=KTIME(I)-KTIME(I-1)
       IF(KCHK.GT.30)KFLAG=1
       IF(KCHK.LT.-50000)KFLAG=2
       IF(KFLAG.EQ.1)KTIME(K)=KTIME(K)-400
       IF(KFLAG.EQ.2)KTIME(K)=KTIME(K)+60000
       IF(KFLAG.EQ.2)SCATS(K)=SCATS(K)+3600.0
    2  CONTINUE
  202 CONTINUE
C
C  THESE STATEMENTS COMPUTE WHICH SCATTEROMETER DATA IS AT 10 SECONDS
C
      DO 9 K=1,NUMBSO
        KTEN(K)=0.0
        KTEMP=KTIME(K)/100
        KDIFF=KTIME(K)-(KTEMP*100)
        MM=ISIGZ(K,4)
        IF(KDIFF.LE.3)KTEN(K)=FLOAT(MM)/10.0+0.5
        IF(KDIFF.GT.96)KTEN(K)=FLOAT(MM)/10.0+0.5
        IF(KTEN(K).GT.5.0)KTEN(K)=KTEN(K)-1.0
    9 CONTINUE
C
C  THESE STATEMENTS FIND DOWNTRACK LOCATION OF THE SIGMA ZERO'S
C
       I=1
      DO 3 K=1,NUMBSO
        SCATY(K)=0.0
        SCATX(K)=0.0
   32     IF(SCATS(K).LT.ACSEC(I)) GO TO 3
          IF(SCATS(K).LT.ACSEC(I+1))GO TO 33
        I=I+1
        IF(I.GT.NUMBAC)GO TO 203
          GO TO 32
   33   RANGE1=ACSEC(I+1)-ACSEC(I)
        RANGE2=SCATS(K)-ACSEC(I)
        RATIO=RANGE2/RANGE1
        L=I+1
        IF(I.EQ.1)GO TO 13
        ALOFF=TOTX(L)-TOTX(L-1)
        YYOFF=TOTY(L)-TOTY(L-1)
        DCOFF=DECORR(L)-DECORR(L-1)
        SCATY(K)=(YYOFF*RATIO)+TOTY(L-1)
        SCATX(K)=(ALOFF*RATIO)+TOTX(L-1)
        SMEAR(K)=(DCOFF*RATIO)+DECORR(L-1)
          GO TO 3
   13   SCATX(K)=TOTX(L)*RATIO
    3 CONTINUE
C
C  THESE STATEMENTS WRITE OUT THE FILES TO DISK
C
  203 CONTINUE
      DO 4 I=1,NUMBAC
    4   WRITE(12,103)TOTX(I),TOTY(I),ITEN(I)
  103 FORMAT(' ',3F10.2)
      DO 5 K=1,NUMBSO
    5   WRITE(13,104)C1,C2,C3,ILINE,IRUN,SMEAR(K),SCATX(K),SCATY(K),
     1    KTEN(K),(ISIGZ(K,ML),ML=1,10)
  104   FORMAT(' ',3I1,1X,I1,'/',I1,1X,F4.0,1X,F6.0,1X,F5.0,
     1    1X,F4.0,1X,10I4)
      STOP
      END
```

Figure A-1.- Concluded.

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FILE: SCAT      EXEC      A                          CONVERSATIONAL MONITOR SYSTEM

GLOBAL TXTLIB CMSLIB FORTMOD2
FILEDEF 5 READER (PERM
FILEDEF 6 DISK SCAT LISTING D (PERM RECFM F
FILEDEF 7 PUNCH (PERM
FILEDEF 10 DISK 61 PDATA1 D (PERM RECFM F LRECL 132 BLKSIZE 132
FILEDEF 11 DISK 61 PDATA4 D (PERM RECFM F LRECL 132 BLKSIZE 132
FILEDEF 12 DISK 61 YDATA1 D (PERM RECFM F LRECL 80
FILEDEF 13 DISK 61 YDATA4 D (PERM RECFM F LRECL 80
FILEDEF 15 TERMINAL (PERM
FILEDEF 16 TERMINAL (PERM
LOAD SCAT
START
```

Figure A-2.- Execute file for program SCAT.

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```
CMS FILEDEF FILE1 DISK FILE1 YDATA1 D;
CMS FILEDEF FILE4 DISK FILE4 YDATA4 D;
DATA  PART1 PART2;
  INFILE FILE1;
  INPUT X Y TIC;
  IF TIC = 0.0 THEN TIC=.;
  YTIC=1.0*TIC;
  IF X LE 40000 THEN OUTPUT PART1;
  IF X GE 20000 THEN OUTPUT PART2;
DATA  PART3 PART4;
  INFILE FILE4;
  INPUT @15 X 6.0 @28 TTIC 4.0 @45 YI 4.1;
  AA=((YI+10.0)/3.0)*1000.0;
  IF TTIC = 0.0 THEN TTIC=.;
  Y2=AA+4000.0;
  YYTIC=TTIC+10;
  YTIC2=(YYTIC/3.0)*1000.0+4000.0;
  DROP YYTIC AA;
  IF X LE 40000 THEN OUTPUT PART3;
  IF X GE 20000 THEN OUTPUT PART4;
DATA PLOT1;
  MERGE PART1 PART3;
  BY X;
DATA PLOT2;
  MERGE PART2 PART4;
  BY X;
PROC PLOT DATA=PLOT1;
  PLOT X*Y='*' X*YTIC='!' X*Y2='*' X*YTIC2='!'/OVERLAY
    HAXIS=-3000 TO 9000 BY 1000
    VAXIS=0 TO 40000 BY 1000
    HSPACE=10 VSPACE=8
  HREF=0 3000 3150 7333
  VREF=0 TO 40000 BY 5000
  VPOS=350 ;
PROC PLOT DATA=PLOT2;
  PLOT X*Y='*' X*YTIC='!' X*Y2='*' X*YTIC2='!'/OVERLAY
    HAXIS=-3000 TO 9000 BY 1000
    VAXIS=20000 TO 62000 BY 1000
    HSPACE=10 VSPACE=8
  HREF=0 3000 3150 7333
  VREF=20000 TO 62000 BY 5000
  VPOS=350 ;
```

Figure A-3.- Computer listing for program PLOT.

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```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                    C
C    THIS PROGRAM IS THE THIRD OF THREE PROGRAMS USED TO PROCESS     C
C    THE COLBY ASME SCATTEROMETER DATA.  THIS PROGRAM SEPERATES THE  C
C    DATA INTO FILES FOR EACH SAMPLED FIELD ALONG THE FLIGHT LINE.   C
C                                                                    C
C    THE INPUT VARIABLES FROM UNIT 9 ARE:                            C
C                                                                    C
C     CODE   = SEE TABLE IN TEXT FOR EXPLANATION                     C
C     ILINE  = THE FLIGHT LINE NUMBER                                C
C     IRUN   = THE NUMBER OF THE RUN                                 C
C     DECORR = THE DECORRELATION DISTANCE (SEE TEXT)                 C
C     SCATX  = THE DOWNTRACK DISTANCE (IN FEET) OF THE DATA          C
C     SCATY  = THE DISTANCE TO THE SOUTHERN/EASTERN FIELD            C
C              BOUNDARIES                                            C
C     ISIGZ  = THE ARRAY CONTAINING THE SCATTEROMETER DATA           C
C                                                                    C
C    THE INPUTS FROM UNIT 10 ARE:                                    C
C                                                                    C
C     IFLD   = AN ARRAY CONTAINING THE NUMBERS OF THE SAMPLED        C
C              FIELDS IN THE FLIGHT LINE                             C
C     START  = THE DOWNTRACK DISTANCES OF THE FIELDS IN THE LINE     C
C     XWIDE  = THE LENGTH OF THE FIELDS (ALONGTRACK)                 C
C     YWIDE  = THE WIDTH OF THE FIELDS (CROSSTRACK)                  C
C                                                                    C
C    THE OUTPUT VARIABLES ARE:                                       C
C                                                                    C
C      CODE,IFLD,ILINE,IRUN= SEE   ABOVE                             C
C     SMEAR = THE DECORRELATION DISTANCE                             C
C     X     = NUMBER OF FEET FROM NORTHERN FIELD BOUNDARY            C
C     Y     = NUMBER OF FEET FROM THE WESTERN FIELD BOUNDARY         C
C     SCAT  = THE ARRAY OF THE SCATTEROMETER DATA                    C
C                                                                    C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      INTEGER*2 IFLD(15),ISIGZ(510,10),SCAT(15,10),SMEAR(15),X(20),Y(20)
      REAL START(15),XWIDE(15),YWIDE(15),SCATX(510)
      REAL DECORR(510),SCATY(510)
C
C  READ THE INPUT FILES
C
      READ(9,100)IC1,IC2,IC3,ILINE,IRUN,DECORR(K),SCATX(1),SCATY(1),
     6  (ISIGZ(1,N),N=1,10)
  100    FORMAT(1X,3I1,1X,I1,1X,I1,1X,F4.0,1X,F6.0,1X,F5.0,6X,10I4)
      DO 1 M=2,510
       READ(9,101,END=11)DECORR(M),SCATX(M),SCATY(M),(ISIGZ(M,N),N=1,10)
  101    FORMAT(9X,F4.0,1X,F6.0,1X,F5.0,6X,10I4)
        SCATY(M)=SCATY(M)+630.0
    1 NUMB=M
   11 CONTINUE
      DO 2 N=1,15
        READ(10,102,END=12)IFLD(N),START(N),XWIDE(N),YWIDE(N)
  102    FORMAT(I2,1X,F7.1,1X,F6.1,1X,F6.1)
    2 NFLDS=N
C
C  M IS THE COUNTER FOR INPUT FILE 10
C
   12 M=1
C
C  THIS SECTION LOOKS FOR THE BOUNDARIES IN THE DATA
C
      DO 3 K=1,NUMB
        IF(SCATX(K).LT.START(M))GO TO 3
        L=K+1
        END=START(M)+XWIDE(M)
      DO 4 N=1,20
        IF(SCATX(L).GT.END)GO TO 44
    4 L=L+1
   44   L=L-1
        ARANGE=SCATX(L)-SCATX(K)
C
C  THIS SECTION SETS UP THE FIELD DIMENSIONS
C
        NPTS=L-K+1
        BTWN=0.0
        XW=XWIDE(M)
        YW=YWIDE(M)
        IF(ILINE.EQ.1)XW=0.0
        IF(ILINE.EQ.4)XW=0.0
        IF(ILINE.GE.6)YW=0.0
```

Figure A-4.- Computer listing for program GRID.

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```
      IF(ILINE.GT.4)GO TO 45
C
C  THIS SECTION IS FOR LATITUDINAL FLIGHT LINES
C
       EDGE=(XWIDE(M)-ARANGE)/2.0
      DO 5 N=1,NPTS
       NUM=L-N+1
       X(N)=IFIX(ABS(XW-(EDGE+BTWN)))
       Y(N)=IFIX(YWIDE(M)-SCATY(NUM))
       SMEAR(N)=IFIX(DECORR(NUM))
      DO 6 NN=1,10
    6  SCAT(N,NN)=ISIGZ(NUM,NN)
       KTR=L-N
       BTWN=SCATX(L)-SCATX(KTR)
    5 CONTINUE
       GO TO 55
C
C  THIS SECTION IS FOR LONGITUDINAL FLIGHT LINES
C
   45  EDGE=(YWIDE(M)-ARANGE)/2.0
      DO 7 N=1,NPTS
       NUM=L-N+1
       X(N)=IFIX(XW-SCATY(NUM))
       Y(N)=IFIX(ABS(YW-(EDGE+BTWN)))
       SMEAR(N)=IFIX(DECORR(NUM))
      DO 8 NN=1,10
    8  SCAT(N,NN)=ISIGZ(NUM,NN)
       KTR=L-N
       BTWN=SCATX(L)-SCATX(KTR)
    7 CONTINUE
C
C  PREPARE TO WRITE THE OUTPUT FILES
C
   55 IUNIT=10+M
C
C  WRITE OUT THE FIELDS COMPUTED IN THIS PROGRAM
C
      DO 22 KK=1,NPTS
   22  WRITE(IUNIT,111)IC1,IC2,IC3,IFLD(M),ILINE,IRUN,SMEAR(KK),
     6   X(KK),Y(KK),(SCAT(KK,MN),MN=1,10)
  111       FORMAT(3I1,1X,I2,1X,I1,I1,1X,I3,1X,I4,1X,I4,1X,10I4)
       IUNIT=IUNIT+1
        IF(M.EQ.NFLDS)GO TO 33
       M=M+1
    3 CONTINUE
   33   CONTINUE
      STOP
      END
```

Figure A-4.- Concluded.

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```
FILE: GRID     EXEC     A                    CONVERSATIONAL MONITOR SYSTEM

&CONTROL OFF
&ERROR &GOTO -ERR
REMOTE E TO HOUSTON
SPOOL E HOLD
GLOBAL TXTLIB CMSLIB FORTRAN
FORTRAN GRID
FILEDEF 5 READER (PERM
FILEDEF 6 DISK GRID LISTING A1 (PERM RECFM FA
FILEDEF 7 PUNCH (PERM
FILEDEF 8 TERMINAL (PERM
FILEDEF 9 DISK &1 YDATA A (PERM RECFM F LRECL 80
FILEDEF 10 DISK BNDRY4 ADATA A (PERM RECFM F LRECL 80
FILEDEF 11 DISK &3 ZDATA A (PERM RECFM F LRECL 64
&IF &2 EQ 1 &GOTO -DONE
FILEDEF 12 DISK &4 ZDATA A (PERM RECFM F LRECL 64
&IF &2 EQ 2 &GOTO -DONE
FILEDEF 13 DISK &5 ZDATA A (PERM RECFM F LRECL 64
&IF &2 EQ 3 &GOTO -DONE
FILEDEF 14 DISK &6 ZDATA A (PERM RECFM F LRECL 64
&IF &2 EQ 4 &GOTO -DONE
FILEDEF 15 DISK &7 ZDATA A (PERM RECFM F LRECL 64
&IF &2 EQ 5 &GOTO -DONE
FILEDEF 16 DISK &8 ZDATA A (PERM RECFM F LRECL 64
&IF &2 EQ 6 &GOTO -DONE
FILEDEF 17 DISK &9 ZDATA A (PERM RECFM F LRECL 64
&IF &2 EQ 7 &GOTO -DONE
FILEDEF 18 DISK &10 ZDATA A (PERM RECFM F LRECL 64
&IF &2 EQ 8 &GOTO -DONE
FILEDEF 19 DISK &11 ZDATA A (PERM RECFM F LRECL 64
&IF &2 EQ 9 &GOTO -DONE
FILEDEF 20 DISK &12 ZDATA A (PERM RECFM F LRECL 64
&IF &2 EQ 10 &GOTO -DONE
FILEDEF 21 DISK &13 ZDATA A (PERM RECFM F LRECL 64
&IF &2 EQ 11 &GOTO -DONE
FILEDEF 22 DISK &14 ZDATA A (PERM RECFM F LRECL 64
&IF &2 EQ 12 &GOTO -DONE
FILEDEF 23 DISK &15 ZDATA A (PERM RECFM F LRECL 64
&IF &2 EQ 13 &GOTO -DONE
&TYPE NOT ENOUGH FILEDEF'S IN EXEC
&EXIT
-ERR &TYPE ERROR ENCOUNTERED IN DEFINING FILES
&EXIT
-DONE &TYPE &2 OUTPUT FILES HAVE BEEN DEFINED
LOAD GRID
START
```

Figure A-5.- Execute file for program GRID.